records are monotonously alike in chronicling low temperatures over the whole country.

The Weekly Weather Reports issued by the Meteorological Office are compiled from observations at stations fairly representative of the whole of the British Islands, and the results are grouped into twelve districts. These returns show that the low temperature is not limited to any special area of the United Kingdom, but is common to every part. From the middle of May to the beginning of August there was only one week, ending July 5, in which the temperature was above the average in the western districts of England, Ireland, or the Channel Islands, whilst in the period of seven months from January 4 to August 2 the temperature in the north-west and south-west of England and in the Channel Islands has only been above the average in three weeks—March 29, May 10, and July 5; and averaging the results for the whole of the British Islands, these are the only weeks in which the resultant temperature was above the average, and may fairly be considered the only warm periods during the seven months.

This persistency of low temperature is to be traced over the whole of the past twelve months, commencing with the beginning of August 1885. To the three warm weeks already mentioned there must be added those of November 9 and 30, December 21, and January 4, making seven in all, and these represent the only warm weeks throughout the entire period, and are the only weeks in which the mean temperature for the whole of the British Islands was above the average.

The following table, which is compiled from the Weekly Weather Reports for the fifty-two weeks ending August 2, 1886, shows the number of weeks with the temperature in excess or defect of the average, and the extent of the deficiency for the several districts. The averages used for the comparison are for the twenty years 1861–1880.

	Weeks above the average	Weeks in agreement with average	Weeks below the average				
			1°-2°	3°-4°	5°-6°	7°-8°	9°-10°
Scotland, N. ...	7	6	15	16	6	2	—
Scotland, E. ...	11	4	17	10	7	3	—
England, N.E. ...	12	2	14	13	8	3	—
England, E. ...	9	3	13	11	12	1	3
Midland Counties ...	11	2	12	13	9	2	3
England, S. ...	10	7	14	10	6	2	3
Scotland, W. ...	10	1	23	9	5	4	—
England, N.W. ...	7	—	17	12	11	2	3
England, S.W. ...	7	6	14	13	7	2	3
Ireland, N. ...	9	1	18	15	5	4	—
Ireland, S. ...	8	5	19	10	7	2	1
Channel Islands ...	6	9	20	11	5	—	1

From this it is seen that the highest number of weeks during the year with the temperature above the average was twelve in the north-east of England, whilst the lowest was six in the Channel Islands.

Throwing the weekly values together so as to form a monthly result, it is seen that November 1885 is the only month of the last twelve in which the resultant temperature for the whole of the British Islands was above the average, and then the excess only amounted to 1°; of the remaining eleven months, one was in agreement with the average, one had a defect of 1°, four had a defect of 2°, three a defect of 3°, and two a defect of 4°. The three consecutive months having the greatest deficiency of temperature were January to March, the defect averaging fully 3° for the entire period.

The rainfall for the same twelve months was above the average during the six months September, October, and November 1885, and January, May, and July 1886, the excess being larger in England than in Scotland or Ireland. It was in fair agreement with the average in March and April, and in defect in the four months August and December 1885, and February and June 1886.

CHAS. HARDING

THE PLIOCENE DEPOSITS OF NORTH-WESTERN EUROPE

IN the series of stratigraphical monographs on which the Geological Survey is engaged, the preparation of the volume treating of the Pliocene deposits has been assigned to Mr. Clement Reid. In pursuance of the plan on which these works are being written, I requested him to visit some of the Continental regions where deposits of corresponding age are best developed, and a personal acquaintance with which would extend his knowledge of their English equivalents. He has accordingly spent some time recently in Belgium and Holland, and among other localities visited the well-known exposures of the Diestian beds around Diest and Antwerp. The sections there laid open, the remarkable assemblage of organic remains contained in them, and the peculiar condition in which the shells at Diest have been preserved led him on his return to this country to re-examine the curious deposit of ironstone at Lenham, on the North Downs, in which, so far back as 1857, the occurrence of Pliocene shells was announced by Prof. Prestwich. Doubt was cast upon this identification of the age of these shells: by many geologists they were looked upon as Lower Eocene, though their original discoverer has consistently maintained his opinion. Mr. Reid has now been fortunate enough to obtain a considerable number of additional species that settle beyond doubt the Pliocene age of the Lenham beds, and thus confirm the view of the veteran Oxford Professor. The establishment of this point raises questions of such wide interest in geology that I feel justified in anticipating the appearance of the memoir in which the facts will be detailed. At my request Mr. Reid has drawn up the following report, which briefly embodies the facts he has brought to notice, and touches upon some of the problems which they suggest.

ARCH. GEIKIE

Some years ago Prof. Prestwich announced the discovery of beds of Pliocene age at a height of over 600 feet on the North Downs (*Quart. Journ. Geol. Soc.*, vol. xiv. p. 322). The bad preservation of the fossils, however, led Mr. S. V. Wood, who examined them, to mark all the species as doubtful, though he was inclined to agree that they were probably Pliocene. Owing to the unsatisfactory nature of the palæontological evidence, and apparently also to an accidental mixture of Eocene fossils from other localities, this discovery has been discredited or ignored, though Prof. Prestwich himself has always maintained its accuracy.

Recently, while preparing an account of the British Pliocene beds for the Geological Survey, it has been necessary for me to examine any outlying deposits which have been considered to belong to that period. For this purpose I paid a second visit to Lenham, near Maidstone, having several years ago examined that locality with no satisfactory result, owing to the obscurity of the sections. A number of blocks of fossiliferous ironstone were obtained from pipes in the Chalk—just as the original specimens were found. These were brought to London, carefully broken up, and impressions taken from the moulds of fossils with which the ironstone was filled. By this means a series of casts was obtained very much better than the obscure impressions so doubtfully determined by Mr. S. V. Wood. The result of the examination of these fossils has thoroughly corroborated Prof. Prestwich's view, for there is not a single Eocene species among them. With two or three exceptions they are all known Pliocene forms; some are new to England, though occurring in France and Italy.

The species obtained were the following, my determinations in every case being indorsed by Messrs. Sharman and Newton :—

Pyrula reticulata, Lam.
Nassa prismatica, Broc.
Ringicula ventricosa, J. Sow.
Pleurotoma turrifera (?), *Nyst.*
,, *consobrina* (?), Bellardi (Upper Miocene)
,, *Jouanneti* (?), Des M. (Upper Miocene)
Trophon muricatus, Mont.
Cerithium tricinctum, Broc.
Turritella incrassata, J. Sow.
Fusus, sp. (= an undetermined Red Crag species)
Scalaria clathratula, Turt.
Margarita trochoidea (?), S. V. Wood, var.
Trochus millegranus, Phil.
Natica, 2 sp.
Bulla lignaria, Linn.
Ostrea, sp. (young)
Pecten, 2 sp.
Pectunculus glycimeris, Linn.
Arca lactea, Linn.
,, *diluvii*, Lam. (new to England)
Leda, sp. (not *L. myalis*)
Nucula, sp.
Diplodonta rotundata, Mont., oval var.
Cardium, 3 sp.
Cardita senilis, Lam.
Astarte Basteroti, Laj.
,, *gracilis*, Munster
Tapes, sp.
Gastrana fragilis, Linn.
Tellina donacina, Linn.
Mactra, sp.
Lutraria elliptica, Lam.
Teredo (?)
Terebratula grandis, Blum.
Lunulites (?)
Balanus, sp.
Diadema (?)

The first thing that strikes one in this list is that the whole of the living species are southern forms, and the nearest allies of the extinct species belong to much warmer seas than ours. This, and the general character of the fauna, and proportion of extinct species, lead me to refer the beds to the Older Pliocene period, and to correlate the deposit with our Coralline Crag and with the Lower Crag or Diestian of Belgium. The fossiliferous clay of St. Erth, in Cornwall, I also think is of about the same age, and not newer.

Some curious questions are raised by these recent discoveries, and by others equally remarkable in Belgium and Holland. We now find that, instead of the Older Pliocene period being one of elevation, there must have been wide-spread submergence over great part of Western Europe. A few years since the Coralline Crag was generally considered to be our only representative of the period, and as it did not rise much above the sea-level, it was often assumed that much of the rest of England was dry land. Now it is known that Pliocene beds cap the highest parts of the North Downs, and from the undisturbed position of the shells, unworn, and generally with the valves united, it is evident that the depth of water must have been sufficient to prevent the deposits at the bottom being affected by storms. A subsidence sufficient to allow only 20 or 30 fathoms of water over the highest parts of the North Downs (and the depth in which the Lenham shells lived could hardly have been less) would submerge the whole of the east and south of England, except a few hills.

In Cornwall also there appears to have been a submergence to a considerable depth, for the St. Erth clay was evidently laid down in still water, which would not be found at a less depth than 40 or 50 fathoms in a district exposed like this to the Atlantic swells. The fossils also in that clay point to some considerable depth of water, while the general flattened contour of the country suggests that this district has nearly all been submerged within a comparatively recent period. The lower parts of Cornwall form a smooth, undulating country, out of which rise abruptly the higher hills. Round one of these hills—St. Agnes Beacon—coarse sand is found at a high level. This is probably a beach deposit of the same age as the clay at St. Erth, though all fossils have now disappeared from it. Cornwall seems at that period to have formed a scattered archipelago like the Scilly Islands.

Among the hard rocks of Cornwall denudation does not appear much to have changed the general configuration of the country since the Older Pliocene period. Moreover the Pliocene deposits were probably never continuous or thick, but merely formed patches in sheltered places and round the shores, the rest of the sea-bottom being rocky. In the south-east and east of England, however, the case was different, for the rocks of that region are soft and much more easily denuded. The position of the Lenham beds, at the very edge of an escarpment, over 600 feet above the sea, indicates that the great valleys of the Thames and Weald have to a large extent been excavated since Pliocene times.

On the other hand, the question arises whether the elevation of the Wealden axis was still in progress during the Pliocene period. That the greater part of this enormous disturbance had been completed before that period seems proved by the absence of any Pliocene beds in the Hampshire or London basins in the synclinal folds parallel with the Weald. But there is possibly evidence of less violent movements of upheaval in the different levels at which Older Pliocene beds now occur. We find the Coralline Crag slightly above the present sea-level, the Lenham beds 610 feet above, while at Utrecht deposits of about the same age are found at a depth of at least 1140 feet below the sea, and their bottom has not yet been reached.[1] If the movements in North-Western Europe have been regular and of equal amount everywhere, then, taking the Downs near Lenham as the starting-point, with a depth of 20 fathoms, we should expect to find in the Coralline Crag the deposits and fauna of 120 fathoms, and at the bottom of the well at Utrecht those of 310 fathoms.

A Pliocene fauna of over 300 fathoms would be most interesting to examine, but of such a fauna no trace has yet been detected anywhere in North-Western Europe. The Pliocene deposits, though now at such different levels, are shown by their included fossils to have been laid down in about the same depth of water. Though differing much in mineral composition at the various localities, they nevertheless agree as closely in regard to their shells as the very different nature of the sea-bottoms would lead us to expect. The whole 1143 feet of Pliocene and Pleistocene beds at Utrecht consists of essentially shallow-water deposits, pointing to a continuous depression.

Were we to assume that the present positions of the Pliocene deposits of the north-west of Europe represent the relative depths at which the beds were originally laid down, a curious difficulty would present itself in any attempt to compare the Pliocene and recent sea-bottoms. Any deep depressions in the seas around England are now filled with cold water and contain an Arctic fauna. In similar depths during the Pliocene period one would expect to find a similar fauna, unless there existed, as in the Mediterranean, a barrier to cut off the Polar currents, or unless there was at that time no cold area at the Pole. Neither of these explanations seems sufficient, and it is more probable that those geologists are right who maintain that the direction of the movements in areas of subsidence or elevation remains the same during long periods. Holland may thus have undergone continued, though probably intermittent, depression since the early part of the Pliocene period ; thus allowing the accumulation of a great thickness of shallow-water Newer Tertiary beds. The axis of the Weald, including the Downs near Lenham, has been correspondingly elevated. Suffolk was little affected, and the deposits were therefore, in that district, thin and largely of organic origin.

I do not bring forward these conclusions as to elevation and submergence as indisputable facts, but merely as the results of my recent studies in the Pliocene beds at home and on the Continent. Any day new discoveries may profoundly modify our views, but the curious facts will remain, that Northern Europe has yielded only a shallow-water Pliocene fauna, and no trace of boreal outliers such

[1] See Dr. J. Lorié, "Contributions à la Géologie des Pays-Bas," *Archives du Musée Teyler*, ser. ii. vol. ii. part 3.

as occur in our existing seas—and this notwithstanding the very different levels at which Pliocene beds now occur

CLEMENT REID

EARTHQUAKE-RECORDERS FOR USE IN OBSERVATORIES

TWO years ago the writer described in NATURE (vol. xxx. pp. 149 and 174) some of the instruments which he had designed and used in Japan for the registration and analysis of earthquake movements. In response to applications from the directors of several observatories, who wished to add seismometric apparatus to their other equipment, arrangements were some time ago made with the Cambridge Scientific Instrument Company for the manufacture of instruments by aid of which the observation of earthquakes might become part of the ordinary work of any meteorological or astronomical station where such movements occasionally occur. In the design of these seismographs the object has been kept in view of

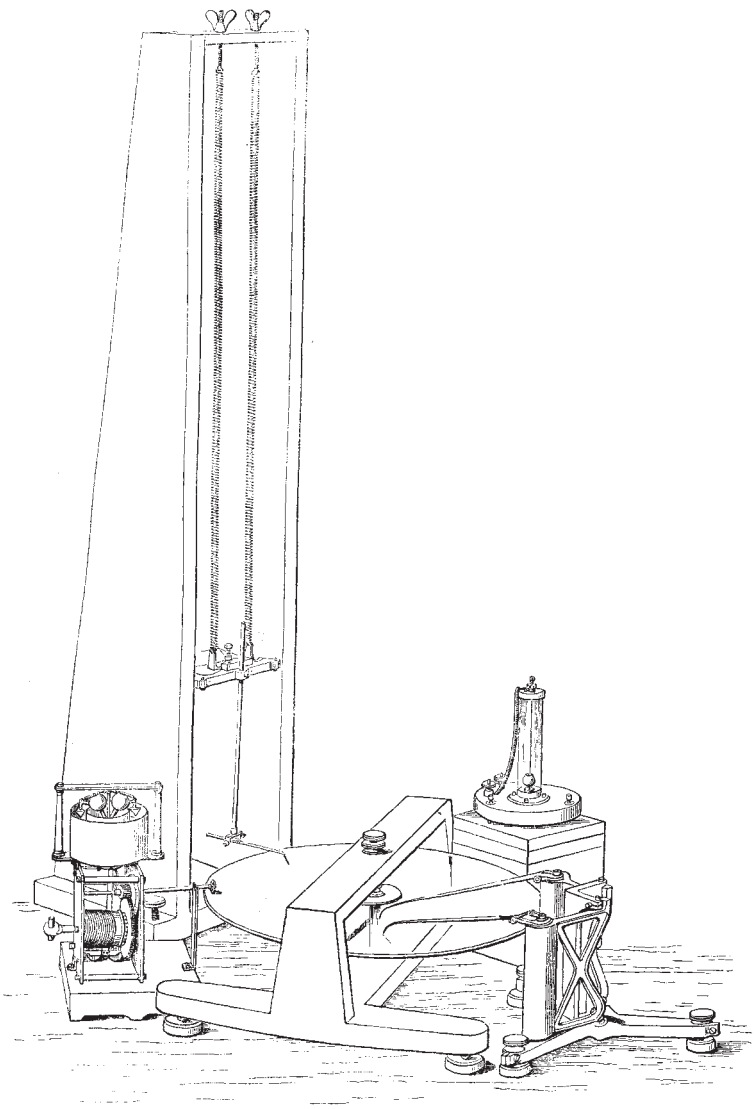

FIG. 1.—Complete three-component seismograph, for motions in all direction.

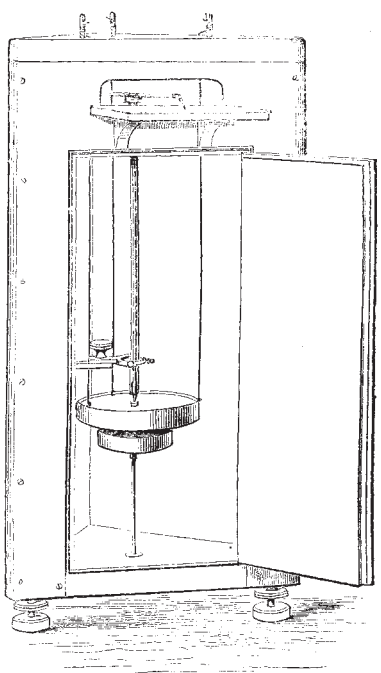

FIG. 2.—Duplex pendulum seismograph, for horizontal motion.

making them easily capable of use by observers who have not made seismometry a special study. They are entirely self-recording, and require little attention during the long intervals which must, in most situations, be expected to elapse between one period of activity and the next.

One group of instruments is arranged to give a complete record of every particular of the movement by resolving it into three rectangular components—one vertical and two horizontal—and registering these by three distinct pointers on a sheet of smoked glass which is made to revolve uniformly by clockwork. A single earthquake always consists of many successive displacements of the ground; hence the record traced by each pointer on the moving plate is a line comprising many undulations, generally very irregular in character. The amplitude, period, and form of each of these are easily measured, and by compounding the three we obtain full information regarding the direction, extent, velocity, and rate of acceleration of the movement at any epoch in the disturbance.

This group of instruments is shown in Fig. 1. In the centre is the plate of smoked glass, which gets its motion